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HIGH EFFICIENCY GAS HEATING SYSTEMS – A REVIEW

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Abstract: This paper reviews modern versions of high efficiency gas heating systems, presenting operating principles and constructive structures, and highlighting the benefits of their use both in terms of thermal efficiency and in terms of regarding the reduction of pollutant emissions into the atmosphere. This issue is of a particular importance for the implementation of viable solutions for ensuring the thermal energy in rural households in our country, where natural gas is available.
Keywords: gas heating systems, high thermal efficiency, low pollutant emissions

INTRODUCTION

The use of natural gas to heating systems from rural households, where available, is particularly profitable for the benefits it offers both from an economic and environmental points of view.

From an economic point of view, the burning of natural gas for the production of thermal energy is the cheapest process compared to the burning of other conventional fuels. Figure 1 shows the results of a study made in March 2015, in United Kingdom of Great Britain, regarding the cost of the producing of 1 kWh of heat through different thermal energy production processes.

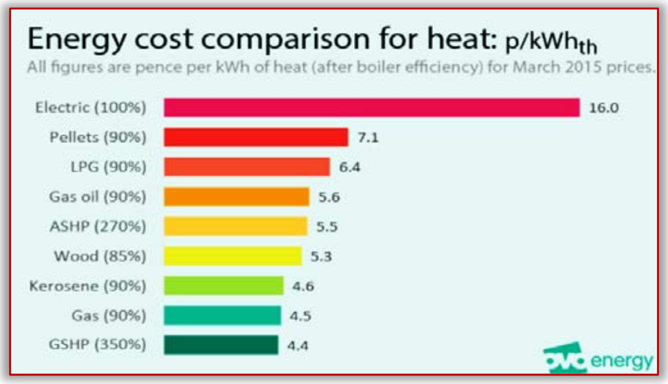

Figure 1 – The cost of producing 1 kWh of thermal energy by different heat production processes [10]

In terms of emissions to the atmosphere, gas burning produces the smallest amount of fine particles compared to the amounts of particles produced by combustion of the other conventional fuels (Figure 2).

Also, the carbon footprint resulting from the burning of natural gas is the smallest compared to those resulting from the combustion of the other categories of conventional fuels (Figure 3). Both situations are particularly favourable from the point of view of environmental protection.

Modern heating systems based on the burning of natural gas can be divided into two main categories, namely: indoor air heating systems with furnaces and boiler heating systems with boiler and radiator network.

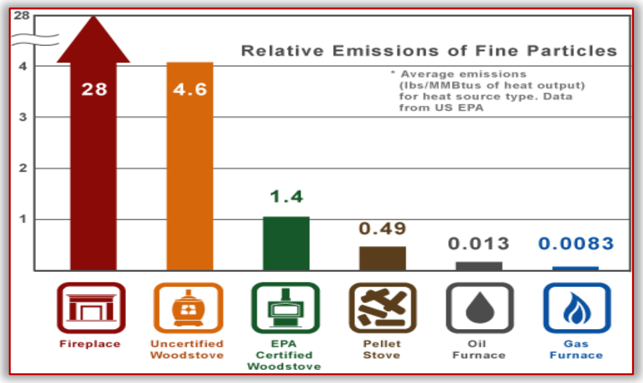

Figure 2 – Solid suspensions emissions produced by different conventional fuels burning [3]

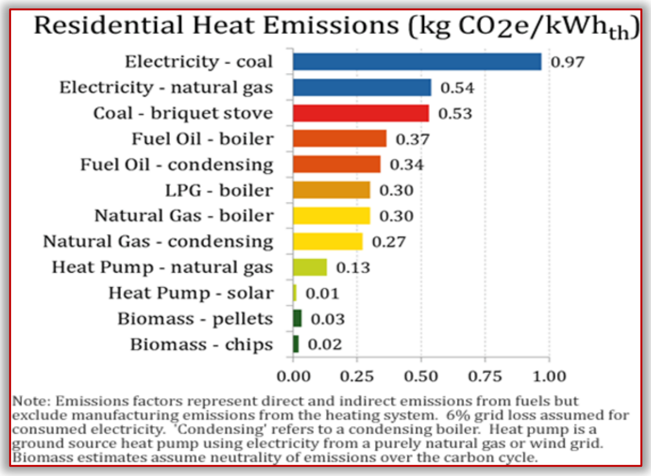

Figure 3 – The carbon footprints produced by different conventional fuels burning [11]

INDOOR AIR HEATING SYSTEMS WITH FURNACES

Currently, modern indoor air heating systems can be classified according to the following criteria: the air circulation mode through the furnace heating system and the transmission efficiency of the thermal energy produced by combustion of the natural gas to the air flow through the furnace heating system.

It should be noted that the efficiency of a heating system with furnace or boiler is measured by annual fuel efficiency (AFUE). Thus, an AFUE of 90% means that 90% of the fuel energy becomes heating energy for home, and 10% escapes out through the vent pipe and through the heating system jacket [6].

According to the air circulation mode through the furnace heating system there are furnace heating systems with free air circulation (by convection) and furnace heating systems with forced air circulation.

The free air circulation heating systems are characterized by constructive simplicity, reduced operating and maintenance costs and reduced thermal energy transmission efficiency (55–65% AFUE to the oldest up to 70% AFUE to the modern ones) [7].

An example of such a modern heating system is shown in the scheme from Figure 4 where it is observed that the gas burner is mounted in a combustion chamber located directly on the outside wall of the home, provided with combustion air intake duct and exhaust fumes. In direct contact with combustion chamber is placed an air circulation channel through which the indoor air enters and heats.

The circulation through the air heating channel is made by convection as follows: the cold indoor air is admitted through the bottom entrance of the channel, contacts the wall of the combustion chamber and increases its temperature, and due to the fact that its density is decreasing, it rises and is discharged through a distributor on the top of the channel, like warm air producing the heating of the room.

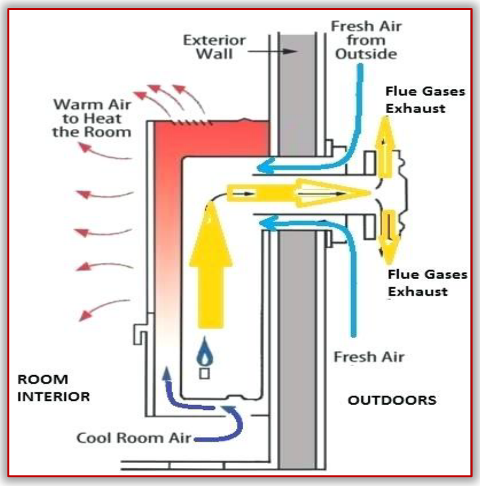

Figure 4 – Heating system with convective air circulation [4]

This heating system is characterized by a very simple construction, easy operation and maintenance, and due to the positioning of the pipes for air intake for gas combustion and flue gas discharge, the efficiency of transmitting thermal energy to the indoor air is satisfactory.

The forced–air heating systems are more complex and more sophisticated in terms of exploitation and maintenance but are also more efficient in terms of transmitting thermal energy to the air that needs to be heated.

Thus, from the point of view of the efficiency of transmitting thermal energy to the air to be heated, forced–air heating systems can be classified into three categories, namely: conventional forced–air heating systems, mid–efficiency forced–air heating systems and high efficiency forced–air heating systems.

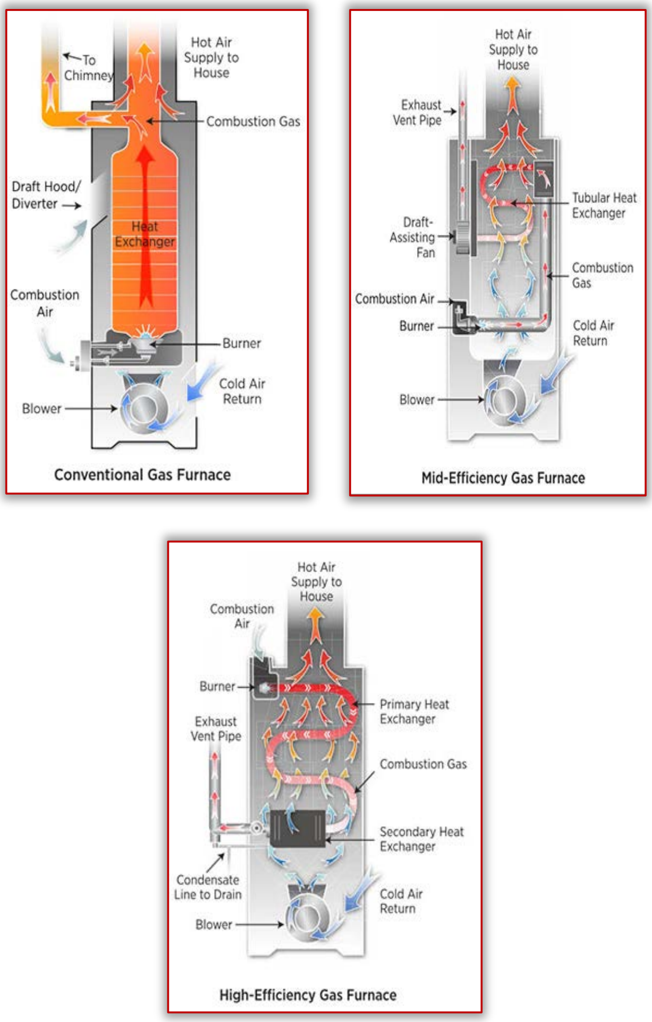

Figure 5 – Principal schemes of forced–air heating systems [7]

Conventional forced–air heating systems (Figure 5a) are the classical heating systems where the in–room air to be heated is introduced into the system through its lower part by means of a fan/exhauster and brought into contact with the wall of the combustion chamber where the gases are burnt, increasing its temperature and then being discharged to the room through a distributor placed on the top of the system. This type of system has 56–72% AFUE efficiency, with the best performing at 78% AFUE.

Mid– efficiency forced–air heating systems (Figure 5b) are the heating systems in which the in–room air to be heated is circulated through the system via a fan/exhauster taking up the energy of the flue gas by means of a tubular heat exchanger placed in their flow direction. It is mentioned that in order for the heat transfer to be as efficient as possible, an auxiliary fan/exhauster is provided in the system to uniform the flue gas flow through the heat exchanger tube. This type of systems have increased efficiency of 80–82% AFUE.

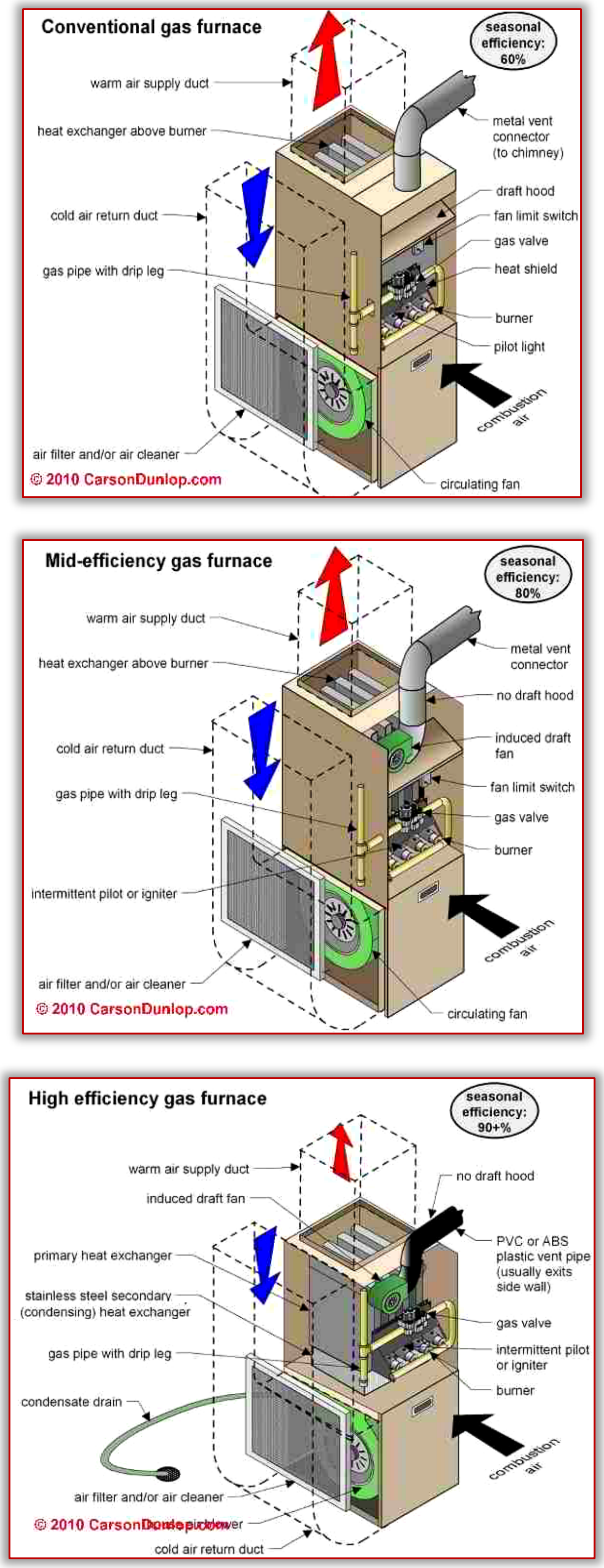

Figure 6 – Constructive structures of forced–air heating systems [8]

High efficiency forced–air heating systems (Figure 5c) are the heating systems to which the in–room air to be heated is circulated through the system by means of a fan/exhauster, taking the energy of the flue gas through a tubular heat exchanger, similar to that of the mid–efficiency systems. In addition, because during the gas burning process, approx. 12% of the heat energy is taken up by the water vapours in form of latent heat, a secondary heat exchanger is introduced into the system to recover this heat energy by condensing the water vapours from the flue gas stream. In this way, to this type of heating systems the efficiency increases considerably to 90–98% AFUE.

On the basis of these considerations, it is mentioned that the high efficiency forced–air heating systems are called condensing air heating systems, while the mid–efficiency forced–air heating systems are called non–condensing air heating systems.

Figure 6 shows the constructive structures of forced–air heating systems. Thus, in Figure 6 up left, is shown the constructive structure of a conventional air–forced heating system, in Figure 6 up right, is shown the constructive structure of a non–condensing air–forced heating system, and in Figure 6, down, is shown the constructive structure of a condensing air–forced heating system.

At present, in Europe and the United States, the most widely used air heating systems are the condensing and non–condensing air heating systems, which have replaced conventional classic heating systems, with the tendency of imposing the high efficiency condensing air heating systems.

By comparing the condensing and non–condensing air heating systems, it can be argued that condensing air heating systems have the following advantages: much higher efficiency, thereby ensuring a substantially reducing of the long–term operating costs, low flue gas temperature (about 55°C, compared to 180°C for the non–condensing systems), very low heat loss in combustion exhaust and significantly reduced CO_2 emissions. The disadvantages of condensing air heating systems are as follows: higher investment and installation costs, corrosion problems arise because the produced condensate is acidic, high maintenance costs and relatively low reliability [5].

BOILER HEATING SYSTEMS WITH RADIATOR NETWORK

Boiler heating systems with radiator networks (see Figure 7) are commonly used as household heating appliances and have the important advantage of providing in addition the necessary domestic hot water.

Constructively, the structure of a boiler heating systems consist of a boiler, a radiator network and a hot water supply system. At present, two large boiler heating systems are offered on the market, differentiated by the efficiency of the boiler, namely: conventional heating systems fitted with classic boiler and high efficiency heating systems with condensing boiler.

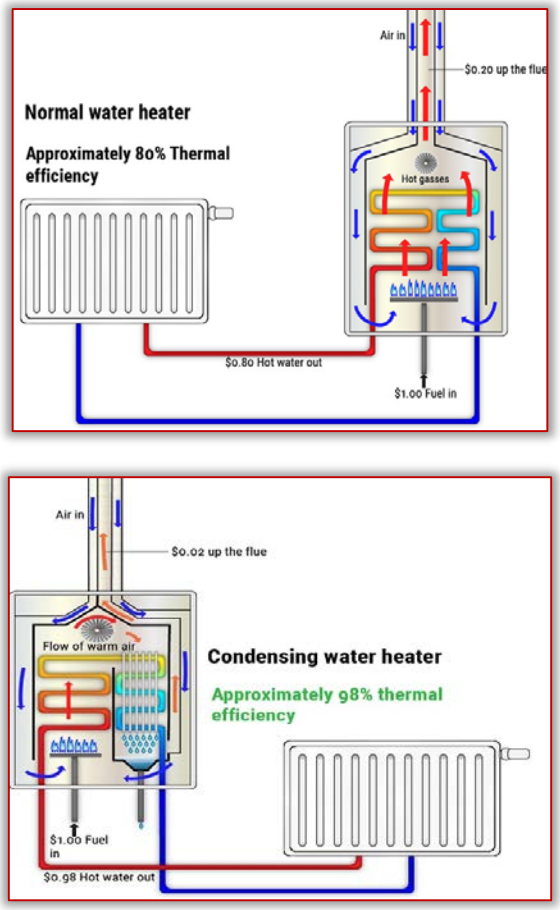

Figure 7 – Principles of heating systems with boilers and radiators network [9]

The fundamental difference between conventional boilers and condensing boilers is that the use the residual heat of the flue gases to preheat the cold return water entering in the boiler. This makes the efficiency of 55–65% AFUE of conventional boilers or 75–78% AFUE of modern non–condensing boilers to increase to 90–99% AFUE in condensing boilers [9].

These outstanding performances of the condensing boilers are mainly achieved by introducing an supplementary heat exchanger, in addition to the heat exchanger for water heating, which transfers the residual heat of the flue gas to return water entering the boiler. The schematic diagram of Figure 8 shows the essential operating differences between a non–condensing boiler and a condensing boiler.

The Figure 9 shows the constructive structure a condensing boiler heating system.

Analyzing comparatively condensing boilers with non–condensing boilers it can be said that the advantages and disadvantages of the condensing boilers are similar to those of the condensing and non–condensing air heating systems. However, it can be mentioned, that the price of high–efficiency boiler systems is at least twice as high as the price of conventional boiler heaters, while the cost of high–efficiency air heating systems is only 30–40% higher than that of a conventional air heating systems [2].

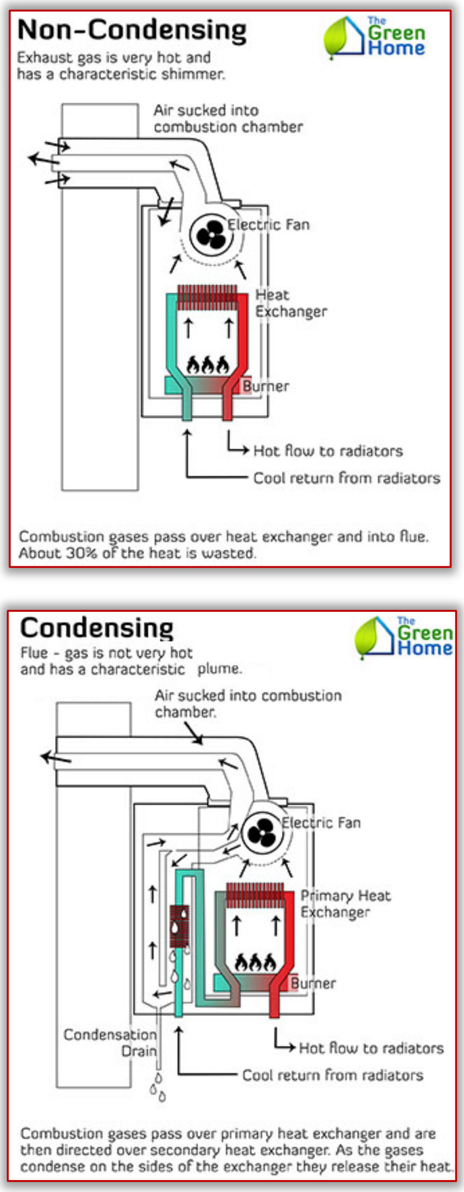

Figure 8 – The essential differences between a non–condensing boiler and a condensing boiler [1]

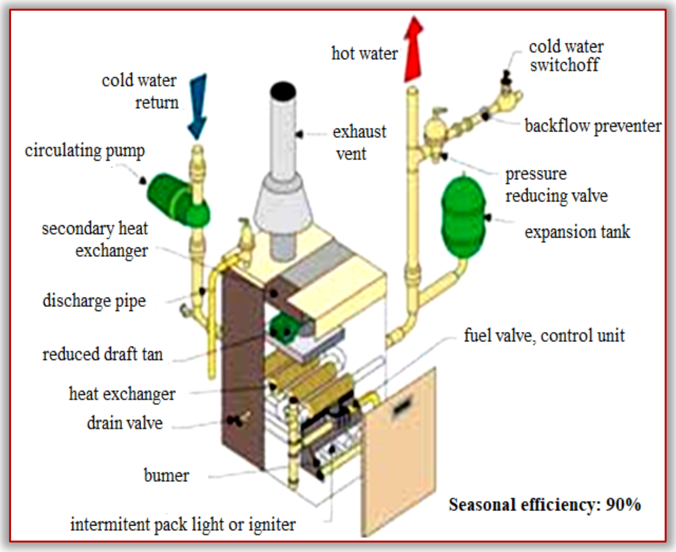

Figure 9 – The constructive structure of a condensing boiler [2]

CONCLUSION

In this paper are presented variants of modern gas heating systems of household, presenting the operating principles, constructive structures and highlighting the benefits of their use in terms of thermal efficiency and in terms of reducing pollutant emissions into the atmosphere. It is can be mentioned that both for the air–heating systems, as well as for the heating systems with the boiler there were created and realized various modern variants with high efficiency, between 90–99% AFUE, which in Europe and the United States tend to increasingly replace conventional gas heating systems.

The problem of introducing modern high efficiency gas heating systems is very important because it constitutes a viable and extremely valuable solutions for ensuring the thermal energy in households in our country rural areas, where natural gas is available.

Note:

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References

[1] ***AGS Heating and Plumbing, (2019), http://www.agsheating.ie/index.php/gas–plumbing–heating–services–dublin/condensing–explain–3
[2] *** American Society of Home Inspectors, (2019), http://www.ashireporter.org/HomeInspe ction /Articles/High– Efficiency–Boilers/14731
[3] *** EPA Burn Wise, (2019), https://www.slideshare.net/mheeke/epa–burn–wise
[4] *** Furnace Heating System, (2019), http://romandou.info/furnace–heating–system
[5] *** GreenMatch, (2015), https://www.greenmatch.co.uk/blog/2015/10/con densing–vs–non–con densing–boilers
[6] *** GOODMAN, Air Conditioning and Heating, (2019), https://www.goodmanmfg. com/ reso urces/hvac–learning–center/before–you–buy/is–a–high–efficiency–furnace–right–for–me
[7] ***Heating and Air Conditioning St. Louis by Galmiche & Sons, (2019), https://www.gal micheandsons.com/hvac–blog/what–is–a–high–efficiency–condensing–furnace
[8] *** InspectAPedia, Encyclopedia of Building & Environmental Inspection, Testing, Diagnosis, Repair., (2019), https://inspectapedia.com/heat/Condensing_Boilers _Furnaces.php
[9] ***Ke Kelit, (2019), https://www.kekelit.co.nz/heat–source–central–heating
[10] ***OVO Energy, (2019), https://www.ovoenergy.com/guides/energy–guides/heating–costsgas–vs–oil–vs–electric–storage–heaters.html
[11] *** Word Enery Council, Comparison of Energy System using Life Cyle Assesment (2014), https://permies.com/wiki/carbon–footprint–heat

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